Potato Leaf Disease Detection Using the Convolutional Neural Network

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Abstract

Plant diseases , a momentous challenge which initial phase of identification diseases plays a prominent function in managing the prevalence of infection and improving the farming industry. The study is concerned about an approach for the development of a potatoes leaves disease's recolonization model by utilizing deep learning. the configuration of 80/20 is employed for training the model. The Adam is used as the optimizer, the augmentation techniques like flips, rotations are applied to avoid overfitting problem in order to improve the performance and robustness of the model. Our model obtained significant result with 97% accuracy and this study can be used to accurately assess potato leaf diseases detection. Our proposed model successfully performs classification on three types of potato leaves, including healthy, early blight, and late blight.

1. Introduction

Farming-crops has pivotal function in economics [1]. as it is essential for producing food in the world the Russian agricultural industry is undergoing transformations due to an increase in the production of agricultural products the Russian government needs to apply innovative techniques in order to increase labor productivity and improve yields. The Russian federation has seen an average growth of 5% in its agricultural sector while developed countries have tapped into more than 55% of their innovation potentials in this sector. To address this, the Russian federation a two-pronged approach is essential first the government should invest in research and development to foster innovation efficiency and productivity second the agricultural industry needs to focus on strengthening its knowledge with superb planning regarding to technology incentives can also be developed to encourage the widespread adoption of technology and innovative techniques [2].

Identification of crops diseases can assist farmers in comprehending how to care farming-foods and cultivate their plants[3]. With the expansion of artificial intelligence (AI), the creation of efficient systems for identifying categorizing and resolving real-world issues has become increasingly key factor for growth of economic. AI can enable farmers to more precisely understand crop disease in order to attention necessary precautions and initiatives to safeguard and enhance crop yield [4].

Gokulnath BV et al [5] present a research survey, which demonstrated commonly machine learning methods applied for object detection of plant diseases through the following steps, image pre-processing, segmentation, features extraction. Particularly to the context of plant disease, Sharma et al. proposed a model using a CNN model for the classification of potato and rice leaf diseases. The authors claim that their proposed model achieved significantly better performance when compared to previews researches [6].

Recently, identification and classification of plant leaves have become popular using machine learning techniques including supper vector machine learning, k-means and convolutional neural networks which assist positive impact on agricultural leading to increased crop production, easier harvesting real-time monitoring and improved business marketing [7].

An automated system has been developed to detect potato leaf image disease and investigated on two famous potato leaf diseases such as late blight and early blight using SVM algorithm. The proposed model abstained 95% accuracy [8].

Aditi singh et al. 2021[9] introduced an approach to identify and classification of potato leave diseases using SVM technique which provides 95.99 % accuracy result in order to associate researcher to gain better insight into plant leaf disease using machine learning.

Another study [10] has been proposed to detect potato leaf disease using transfer learning and CNN network. The findings have been showed that suggested model attained 94.2% accuracy which could be applicable to agriculture experts and researchers in order to realize plant leaf disease using modern machine learning techniques.

We provide our experiences in classifying and identifying plant leave diseases using convolutional neural network CNN to conduct our study we used convolutional neural networks CNNs to identify potato leaf diseases and our proposed model achieved a significant classification accuracy of 97% in comparison to the results of previous researches compare to recently research we used a dataset with a smaller number of training parameters in order to prevent time consume. The aim of this study to replace traditional methods and human labor and to produce better products.

2. Material and Methods

Various machine learning methods have been implemented in this study, we mainly focused on potato leaf disease identification by utilizing Convolutional neural network. Figure 1, shows the workflow of our proposed model.

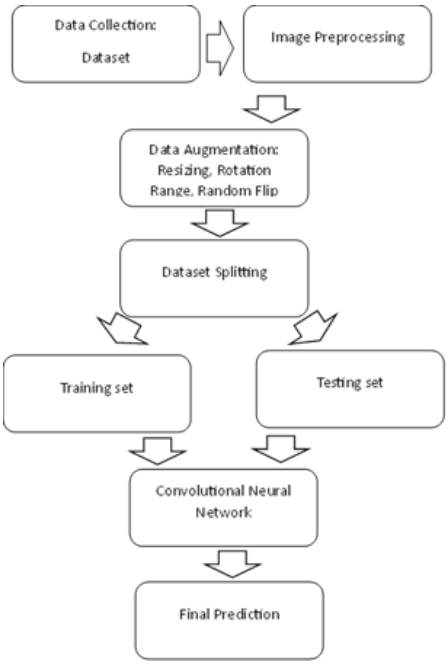

Fig. 1. Proposed Workflow

2.1. Dataset

A handy and well-designed dataset is crucial and effective step for training process of a model [11]. In order to train the model, the dataset is categorized into three classes in order to potato leaf diseases recognition. Figure 1, shows the our datasets including 656 original image , 152 healthy leaf and 504 unhealthy image samples for late bright and early blight leaves potato's. The data augmentation techniques make it possible to increase the size of the dataset to achieved accurate results [12]. after applying augmentation techniques, we obtained 2176 augmented leaf samples of potato leaves. The dataset have been randomly shuffled in order to enhance and modified version of dataset, then, 80 datasets utilized as training set and remaining for testing set. The testing set applied to monitor the final accuracy of the network once the training of the model was completed as indicated in table 1.

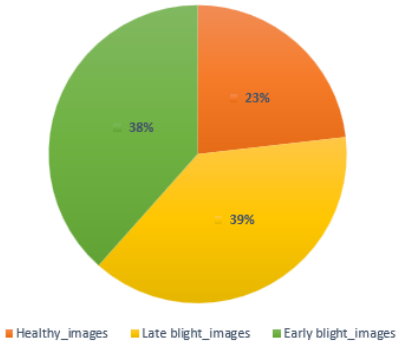

Fig. 2. Original dataset before Augmentation

2.2. Image Preprocessing

Image pre-processing is momentous step in building a high-quality model[13]. prior to train the model, the model the input images typically contain noise and complex backgrounds which are not suitable for training neural network model by applying image preprocessing techniques any distortions and noise can be removed and the images can be enhanced for further processes therefore the input images resized to 256x256 using OpenCV to reduce wasting time and improve the model's performance.

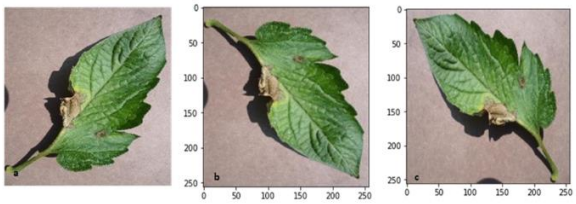

Fig. 3. Generation of leaf images via data augmentation techniques: a) resized image, b) flip, c) rotation

2.2. Data Augmentation

Data augmentation is a well-known technique in deep learning and computer vision which is used to increase the contains of datasets utilizing random transformations such as random cropping, rotation and scaling flipping. having a larger dataset is important to solve overfitting problem which occurs while proposed model learned irrelevant patterns from the training data . To have robustness deep learning model augmentation techniques play outstanding role to improve model performance [14].

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Table 1. Dataset Image with Augmentation

Dataset Class	Potato Dataset
Original Images	656
Augmented Images	2176
Training Dataset	1728
Testing Dataset	448
Classes	03

2.3. Convolutional Neural Network (CNN)

Convolutional neural networks (CNN) are employed to capture high level features from a input dataset. Firstly, it capture low level features which further combine and map them to high-level features in order to classification tasks [15]. convolutional neural networks is a famous neural network which can implement in various aspects such as leaf disease detection and classification [16]. In general, there are prominent steps to build a CNNs. convolution layers generate features map by applying

convolution via input data. The filters have been slided horizontally and vertically by convolution operation [17]. activation function have been employed to effectively convert all negative values into zero in order illustrate non-linearity of model [17] as shown in below equation.

$$f(x)max(0,x)f'(x) = \begin{cases} 1, x > 0 \\ 0, Otherwise \end{cases}$$

Down-sampling of features maps have been occurred in pooling layer for reducing computational training and converting the multi-dimensional vectors to the one dimensional have been done by flattens layers [18]. Subsequently, dense layer received the previews results for predication and classification [19]. Figure 4 illustrated our proposed model for identification potato leaf disease using convolutional neural networks which contains convolution layers, max-pooling layers, flattens and dense layers. table 2 shows the configuration of hyper-parameters of the CNN model architecture.

Table 2. CNN model architecture hyper-parameters configuration

Optimizer	Adam
Batch size	32
Image size	256x256
Channels	3
Epochs	40
Loss	Sparse_categ-rical_crossent-opy

3. Results and discussion

We have trained the CNN model which is able to detect the infected leaf and healthy leaf. Additionally. We used various methods and system dependency to implement our tasks such as installing TensorFlow with python libraries. Furthermore, there are various of plant diseases. So, we have selected three common types of potato leaf diseases in our research. Our images are labeled categorized based on the types of diseases. We employed rectified linear unit (ReLU) show non-linearity to the network [20]. finally, softmax function have been utilized in last layer of deep learning in order to classification and identification potato leaf diseases and to optimize the model, adaptive moment estimation have been used[21]. our research stand out in the agricultural sector because of significant results for classification potato leaf diseases compared to traditional machine learning methods [22,23]. Additionally, we reduced the numbers of parameter to avoid the training time of convolutional neural network model

Our research utilizes more advanced methods that save time and provide a more thorough understanding of plant leaf disease detection using neural networks. Furthermore, our proposed model has been found to be highly effective, achieving a 97% accuracy rate as shown figure 5.

The experiment was conducted on a windows 10 machine with a Core i5 processor, using the Google Colab (Jupyter Notebook) deep learning framework and single 8GB RAM

As a result, our findings offer a valuable addition to the existing literature and demonstrate the potential of AI in revolutionizing the agriculture industry in figure 6,7. This impressive level of accuracy demonstrates the potential of our model to address the challenges and demands of the problem at hand, this study can be useful for researcher in order to gain insight deeply into plant leaf diseases using deep learning algorithms in their further research.

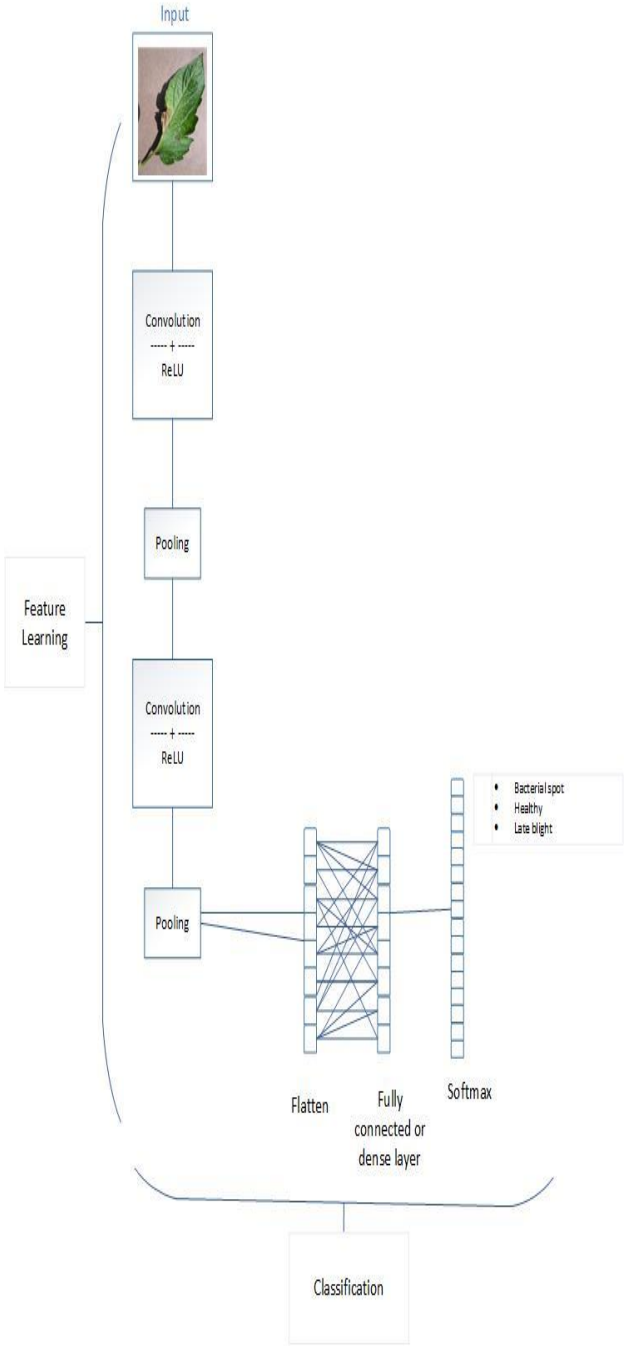

Figure 4. Convolutional Architecture

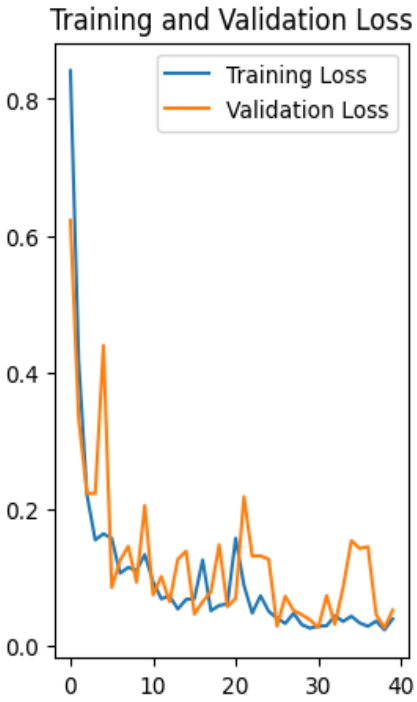

Fig. 5. Training and Validation Loss

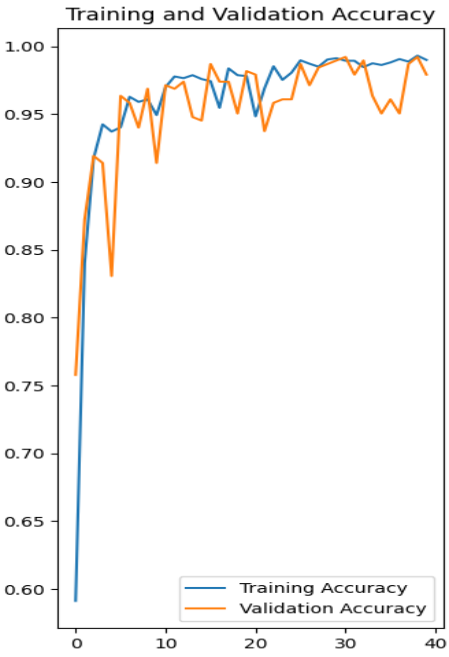

Fig. 6. Training and Validation Accuracy

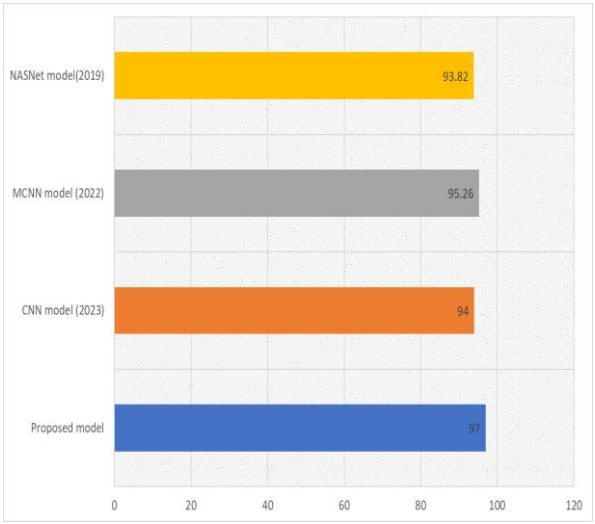

Fig. 7. Comparison accuracy results with related works

4.Conclusion

The agricultural industry plays a critical role in the global economy, as it is responsible for producing the food that feeds the world's population. Historically, traditional methods were used for disease detection in plants and harvesting, which were time-consuming and required expert agricultural knowledge. however, with the advent of Artificial Intelligence (AI), these problems can be addressed more efficiently. By automating various farming operations, AI offers the potential for precise cultivation, better crop yield, and improved quality while using fewer resources. With AI systems assisting in the detection of plant diseases, the overall harvest quality and accuracy can be improved, paving the way for a more sustainable and productive agricultural sector. With the help of modern technologies in agriculture sector we can achieve effective management in order to achieve significant plant products quickly and prevent time consuming.

5. Future plan

We would like to develop our model and create a web application that allows everyone to access and upload images of their plant's leaves. Our model will provide effective suggestions and solutions for common plant leaf diseases. Additionally, it will offer contact information for the nearest agricultural center office, allowing users to consult with agriculture specialists for more accurate results.

6. Acknowledgment

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7. References

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